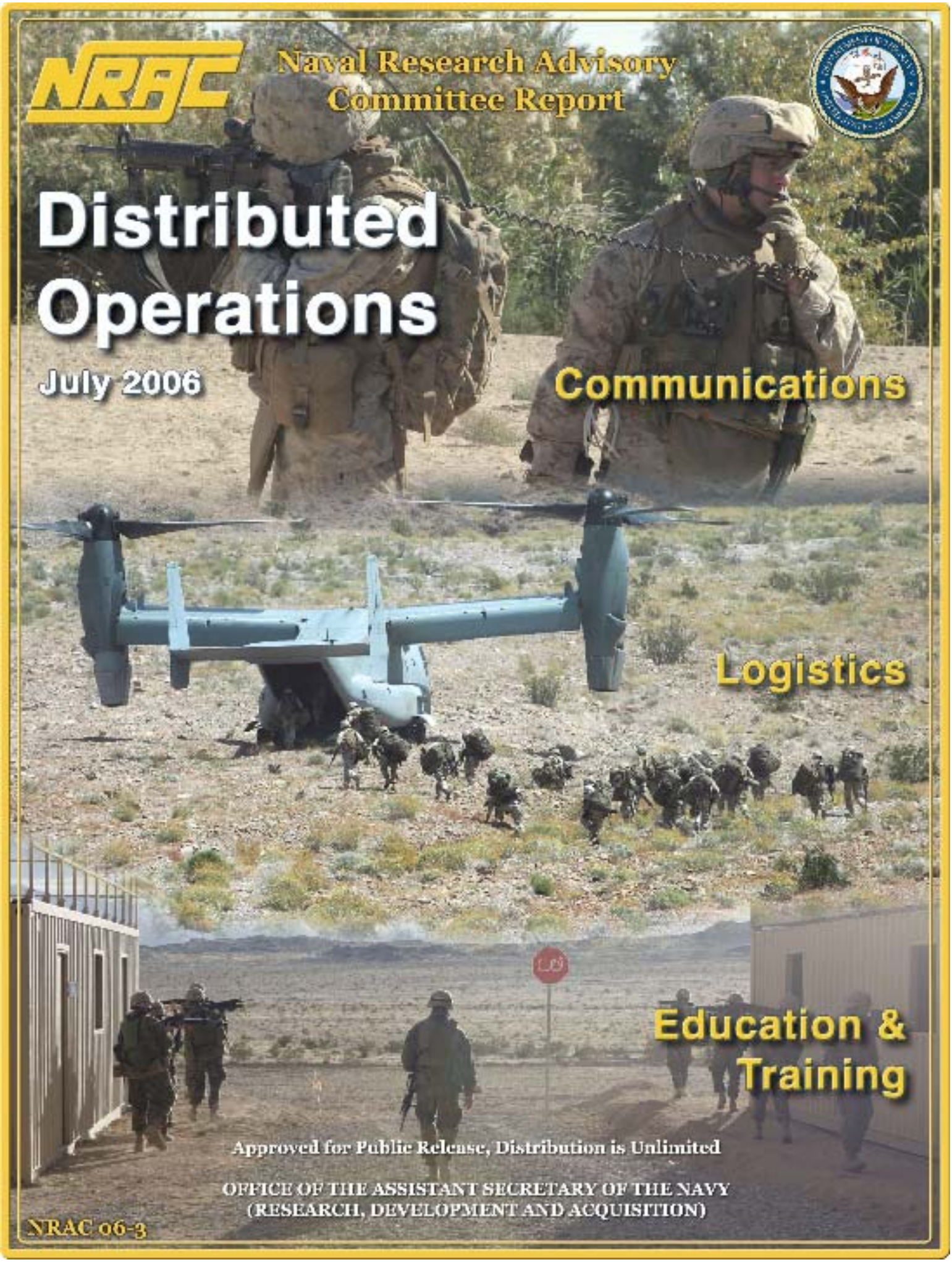

NRAC
Naval Research Advisory Committee Report
Distributed Operations
July 2006
Communications
Logistics
Education & Training
Approved for Public Release, Distribution is Unlimited
OFFICE OF THE ASSISTANT SECRETARY OF THE NAVY
(RESEARCH, DEVELOPMENT AND ACQUISITION)
NRAC 06-3

This report is a product of the U.S. Naval Research Advisory Committee (NRAC) Panel on Marine Corps Distributed Operations. Statements, opinions, recommendations, and/or conclusions contained in this report are those of the NRAC Panel and do not necessarily represent the official position of the U.S. Navy, the U.S. Marine Corps, or the Department of Defense.

Cover: Distributed operations rests on three essential components. Communications among neighboring units and to and from higher echelons, logistical resupply of geographically dispersed units, and education and training for both enlisted infantry and their officers. All of these aspects of military operations will have to be enhanced beyond the requirements for conventional operations.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
19-12-2007	Group Study	February - June 2006

4. TITLE AND SUBTITLE

Distributed Operations: Communications, Logistics, Education & Training

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

J.C. Sommerer, J.M. Feigley, W.A. Neal, N. Polmar, A.M. Andrews. J.T. Tozzi, F.L. Fernandez, C.B. Wallace, P. Fratarangelo, V.J. Gawron, E.R. Kohn

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Naval Research Advisory Committee
875 North Randolph Street
Arlington, Virginia 22203-1993

8. PERFORMING ORGANIZATION REPORT NUMBER

NRAC 06-02

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Assistant Secretary of the Navy (Research, Development and Acquisition)
1000 Navy Pentagon
Washington, DC 20350-1000

10. SPONSOR/MONITOR'S ACRONYM(S)

ASN(RD&A)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

In the Marine Corps' "distributed operations" (DO) concept, distributed squads and platoons control large areas by coordinated tactical actions, acquiring ISR (intelligence, surveillance and reconnaissance) sensor data directly or from external sensors while calling on external firepower and reliable long-range resupply. With small units (vs. battalions) given tactical initiative, their leaders' situation-awareness burdens become major issues, also squads' radio connectivity and casualty care. DO battalions need more radios, as radio links now extend below company level up to 200 km range. DO units must move more equipment greater distances, worsening current soldier overloads. Their resupply and maintenance needs increase sharply over those of non-DO units, yet current air/surface resupply is inadequate for real-time precision delivery at longer range. These issues mandate a unified "DO Marine as system" S&T push by USMC, ONR and DARPA (e.g., robotic ground/air resupply, airborne radio relay, medical sensors, artificial blood), major ONR additions to USMC S&T funding, and maximal leveraging of DO-relevant Army and DARPA S&T.

15. SUBJECT TERMS

combat loads, Marine Expeditionary Rifle Squad, Improvised Explosive Devices

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			William H. Ellis
UNCLAS	UNCLAS	UNCLAS	UU	50	19b. TELEPHONE NUMBER *(Include area code)* (703) 696-5775

Reset

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

This page intentionally left blank

Contents

This page intentionally left blank

Executive Summary

In April 2005, General M. W. Hagee, then Commandant of the Marine Corps, released the white paper entitled *A Concept for Distributed Operations*, which was "intended to promote discussion and to generate ideas for specific combat development initiatives" in the context of "the irregular challenges of Small Wars," enabling small units to function with greater operational initiative and independence. In response, the Marine Corps Combat Development Command (MCCDC) initiated a number of activities, including Limited Objective Experiments conducted by the Marine Corps Warfighting Laboratory (MCWL), to explore the concept of distributed operations (DO). In late 2005, Lieutenant General James N. Mattis, CG MCCDC, requested that the Naval Research Advisory Committee (NRAC) devote one of its annual Summer Studies to DO, comparing and contrasting the emerging concept with conventional operations, determining how selected technology insertions could enable DO, estimating risks associated with various options, and identifying potential show-stoppers. Lieutenant General Mattis' vision was that distributed operations would "unleash the combat power of the young Marine" and his guidance was for NRAC to focus on the "squad level as a system." At the direction of Assistant Secretary of the Navy (RDA) Dr. Delores Etter, NRAC undertook the study during the period February–June 2006. At the time of the study was completed, Lieutenant General Mattis had been reassigned to command the I Marine Expeditionary Force; the study was briefed to his relief as CG MCCDC and Deputy Commandant for Combat Development and Integration, Lieutenant General James F. Amos, who consulted the Panel on implementation through early 2007.

The NRAC Panel was privileged to engage in early discussions on DO's emerging concept of operations where doctrine was still evolving and military experiments were just beginning. Fact-finding by the Panel thus focused on understanding the operational concept, which was the subject of ongoing discussions among uniformed and civilian Marine personnel. NRAC tested its understanding through repeated interactions with MCCDC and MCWL, who largely concurred with the Panel's interpretation and articulation of the approach represented by DO.

In this context, the Panel found that implementation of DO would demand significant effort, including technology development, in three primary areas: communications, logistics, and education and training.

Available, reliable, and secure communications are central to the DO concept, given increased spatial dispersal of small units and the attendant requirement that they have access to remote fires and intelligence, surveillance, and reconnaissance (ISR) resources. To achieve the spatial separations specified by MCWL analysis, very significant augmentation of currently organic communications systems at the platoon and squad levels will be required, adding to both the difficulty of logistical support and training of DO units. Furthermore, the added complexity of the battle space network is a clear risk to DO success, given that many small units will be operating simultaneously in this manner.

Critical to successful execution of DO will be the timely and reliable resupply of spatially dispersed small units through a variety of air and ground assets. In addition,

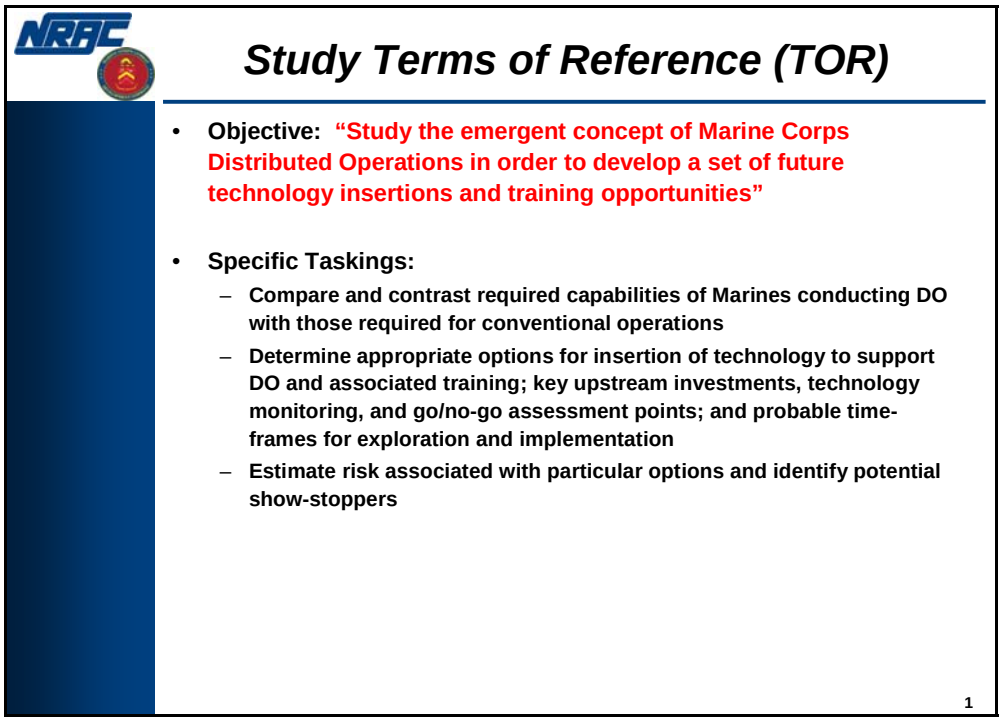
confidence of the squad in timely and accurate resupply will be essential for Marines not to increase further the already excessive individual load carriage requirements typical of Marines in conventional operations. The development of several types of unmanned systems appears to be the most feasible approach to address this challenge.

In addition, Marines conducting DO will need extensive training in communications and logistics support systems, independent tactical decision-making consistent with commander's intent, and cultural and linguistic training enabling the small units to interact with local populations effectively. This additional training, much of which will require the unit as a whole to train together, has significant implications for manpower management and force structure. The Panel found that modern immersive training (borrowing heavily from entertainment industry technology) has an important role to play in supporting these training requirements and potentially in screening of personnel most likely to benefit from the additional training investment. In general, the requirements for DO elevate the infantry Military Operational Specialty (MOS) to be comparable to other highly skilled MOSs.

The Panel's principal recommendation is that the Department of the Navy establish a "DO Marine as a System" Science & Technology (S&T) Program, resourced at approximately $50M/year for the level of challenge represented by DO as a transformational concept of operations. This will require careful prioritization of Marine S&T investments, significant additional resources from the Office of Naval Research (ONR) beyond the current program of record within ONR Code 30 and MCWL, as well as effective leverage of investments by the Defense Advanced Research Projects Agency (DARPA), the Army, and Special Operations Command (as well as DoD investments in Joint infrastructure, such as the Global Information Grid [GIG]).

Additional top-level recommendations include the following:

1. MCCDC should ensure that communications and networking requirements of DO will be supported in planned DoD battle space architecture.
2. The Marine Corps should evaluate the feasibility, desirability, and means of aging the force in order to maximize return on investment in much more highly trained infantrymen.
3. The Marine Corps should retain or establish an "honest broker" (independent of vendors and integrators) to conduct DO communications system engineering.
4. The Marine Corps System Command should elevate the Marine Expeditionary Rifle Squad (MERS) "Program" within the acquisition structure so that programs that provide equipment to MERS are subordinate to it, so that the system engineering required for the squad Table of Equipment can be effective.



Terms of Reference

U.S. Marines fighting in the Global War on Terrorism confront adversaries that are increasingly adaptive, decentralized, and elusive. Recognizing the overwhelming conventional superiority of U.S. forces, these enemies will continue to develop new tactics designed to exploit perceived seams in U.S. capabilities and to otherwise undermine advantages in mobility, firepower, sensing, and command and control. It is essential that U.S. forces continuously adapt their methods of fighting while remaining a flexible combined-arms force.

On April 25, 2005, General M. W. Hagee, then Commandant of the Marine Corps, released the white paper *A Concept for Distributed Operations*, that was "intended to promote discussion and to generate ideas for specific combat development initiatives" in the context of "the irregular challenges of Small Wars," enabling small units to function with greater operational initiative and independence.

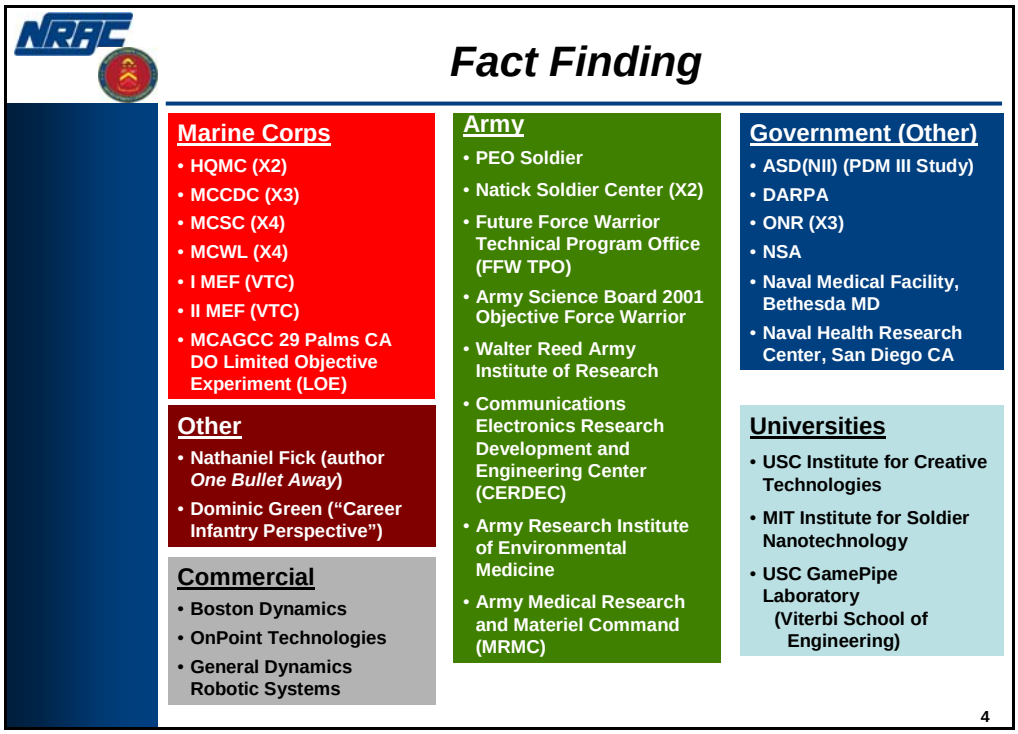
Lieutenant General James N. Mattis, then Commanding General of the Marine Corps Combat Development Command (MCCDC), requested that the NRAC undertake a study of distributed operations (DO) to develop a future set of technology insertions and technology-based training opportunities that would help the Corps meet the evolving challenge discussed in the opening paragraph. Specific tasking to the Panel is outlined in the figure above. Lieutenant General Mattis further amplified the guidance contained in the terms of reference (a complete copy of which can be found in Appendix A), asking the Panel to

1. consider the Marine rifle squad as a system,

2. emphasize enablers for local decision-making consistent with commander's intent,
3. consider enhancement of human performance,
4. consider higher-order effects of DO beyond the rifle squad, including higher echelons of command and the Corps' supporting establishment,
5. focus on the mid-term time scale (about eight years), and
6. conduct its deliberations free from constraint based on cost.

Lieutenant General Mattis' overarching vision was that DO will "unleash the combat power of the young Marine."

On its own initiative, the Panel focused its deliberations at the system-of-systems level to best complement a Defense Advanced Research Projects Agency (DARPA)-funded DO Architecture Study started prior to, and finishing during, the NRAC DO study. The DARPA study focused on defining a set of high-risk, high-payoff technology developments that would support DO.



Fact Finding

One of the principal challenges initially facing the NRAC Panel was to understand the underlying concept of DO. In addition to the initial white paper, the panel found a very wide range of concepts in fact-finding interactions with the Marine Corps and Navy, which necessitated iterative interactions, as outlined in the figure above (where X*N* indicates *N* interactions with the command).

Panel members made two trips to the Marine Corps Air Ground Combat Center at 29 Palms, CA. During the first visit, the entire NRAC membership was given the opportunity to discuss combat operations, training, and equipment with many enlisted and commissioned Marines (most with recent combat experience). Through discussions and visits to units under training, the Panel was better able to understand the combat challenges faced in theater. Subsequently, a subset of the Panel returned to 29 Palms to observe the DO Limited Objective Experiment (LOE).

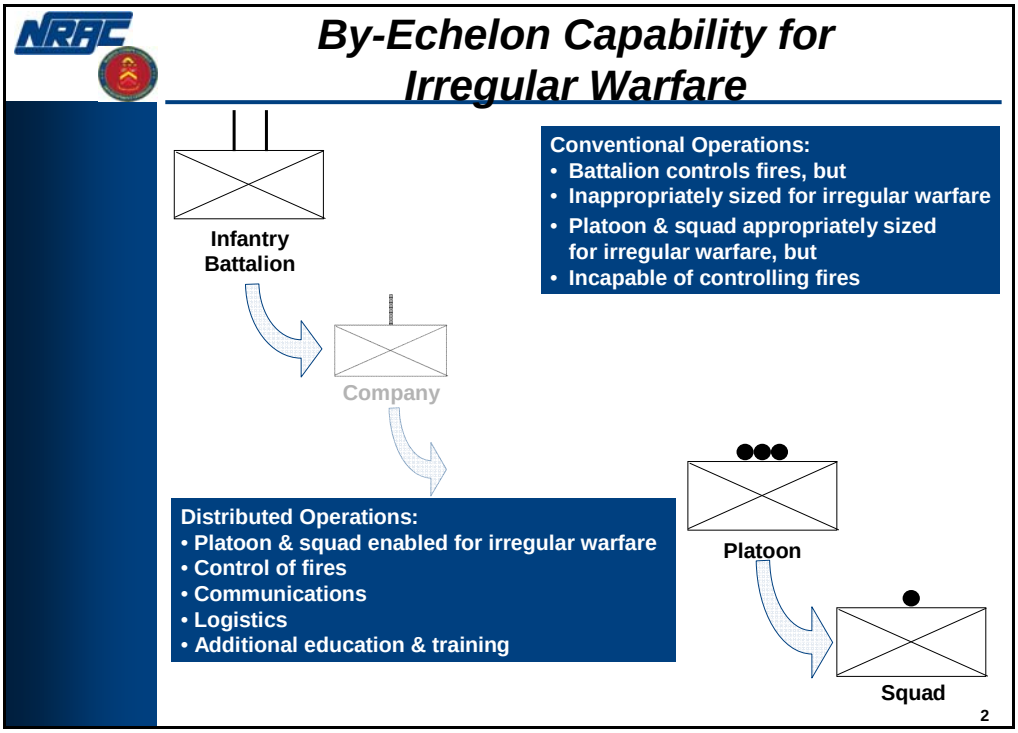
In addition, the Panel solicited perspectives from former Marines with relevant experience. Of course, the Panel also sought information on the maturity of relevant technology from numerous acquisition programs in the U.S. Army, the Office of Naval Research (ONR), and other U.S. Government agencies, as well as commercial industry and academia. Because of the specific charge to investigate the potential for enhancing human performance, a special subteam led by the (statutorily mandated) NRAC medical doctor focused on medical and human factors issues with the Walter Reed Army Institute of Research, the U.S. Army Research Institute of Environmental Medicine, the U.S. Army Medical Research and Materiel Command, the Naval Medical Center in Bethesda, and the Naval Health Research Center in San Diego, CA.

The array of views on DO observed by the Panel was notably dispersed, spanning the conceptual range from "an acquisition strategy for an improved rifle squad with a revised Table of Equipment" to "DO units will be nearly equivalent to Special Operations Forces."

MCCDC identified three principal drivers to enhance a small unit's ability to create an advantage over the enemy, especially in an irregular warfare context. DO is designed to create spatial, temporal, and psychological advantages over an enemy through

1. deliberate use of separation and coordinated interdependent tactical actions,
2. increased access to functional support, especially including fires, and
3. decision-making and initiative, consistent with commander's intent, by small units engaged in combat.

The Panel internalized this perspective as an operational approach that enables influence over larger areas of the battle space than conventional operations through spatially separated small units empowered to call for and direct fires and to receive and act on real-time intelligence, surveillance, and reconnaissance (ISR).

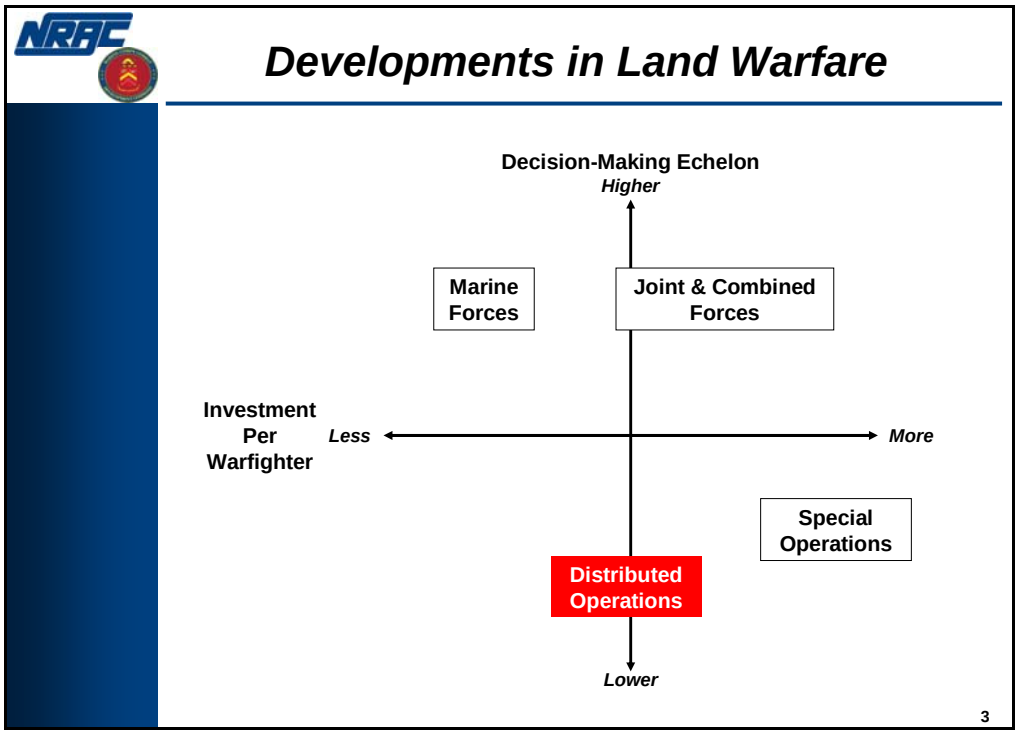


The ability of small units to act on their own initiative, including the call for and direction of remote fires, provides a better impedance match between U.S. forces and the elusive opposition forces in the context of irregular warfare. Thus DO is an approach that pushes the observe, orient, decide, act (OODA) loop to lower echelons of command, where it can cycle faster, in the context of irregular warfare.

The Panel notes that DO is intended to be an additive capability to be used when the tactical situation dictates. Massed forces are still required for many military contingencies. Thus, an essential capability in the context of DO is the efficient re-aggregation of distributed forces to function effectively at the battalion level.

The Panel contrasted DO with other operational concepts in a two-parameter space. In the figure below, the vertical axis shows the lowest command echelon at which independent decision-making, consistent with commander's intent, takes place. The horizontal axis represents the organic combat support upon which the operating concept can depend. This could be parsed essentially as the communications capability, the logistics support, and the training conducted by the unit and received by the individuals. From a business perspective, the horizontal axis represents the investment per warfighter.

Marine units, as deployed in conventional operations, are a relatively low-cost force, where decisions are made in upper echelons. In a joint or combined forces context, both combat capability and investment go up, reflecting the network-centric infrastructure, joint fires, etc.



In the context of irregular warfare, the United States established a Special Operations Command in 1987. This Command has its own organic logistics support, special systems acquired increasingly through independent acquisition, and is enabled by specialized and intensive training. Although this approach involves the use of small units operating with great autonomy, the investment profile for Special Operations Forces (SOF) is such that it is employed primarily in situations of high strategic importance within the battle space or to prepare the battle space. In particular, SOF are used especially where the strategic importance of the target can be identified well in advance.

DO, on the other hand, is designed to harvest fleeting tactical opportunities broadly across the battle space, with many more independently operating small units.

Although the envisioned investment per warfighter is intended to be smaller than in the case of SOF, it is important to note that enabling DO will require increased investment per warfighter over conventional Marine Corps operations.

The Panel concluded that enabling the Marine Corps for DO has two critical components: (1) supporting the Marine unit through communications, education and training, and logistics and (2) enabling the Marine for DO both mentally and physically. Both of these will be discussed in the remainder of the report, beginning with enabling the individual Marine.

Finally, it should be noted that due to the limited time available for this study, alternative concepts of operation for ISR systems and fire support were not considered. The Panel focused on enabling Marine rifle squads to direct remote fires as currently constituted and projected for the mid-term future and to make use of ISR products as currently produced.

The next five sections of this report address DO's implications for the individual Marine, communications systems, logistics, education and training, and the Marine Corps supporting establishment. In each section, the approach taken, in accordance with the terms of reference, is to compare and contrast the capabilities required (in the domain of discussion) for DO versus conventional operations. For each domain, this contrast led to a set of findings and conclusions that either guided subsequent analysis or served as the basis for recommended technology insertion opportunities, investment strategies, or actions for Department of the Navy leadership.

The Individual Marine

	Conventional Operations	Distributed Operations
Mental Demands	• Decision-making: centralized and directed • Situational awareness at battalion and higher echelons • Verbal communications at and below platoon level • Sleep deprivation and physical fatigue degrades decision-making skills	• Decision-making: decentralized, consistent with commander's intent • Situational awareness at platoon and squad levels over large area • Electronic communications extended below company level • DO CONOPS exacerbates impact
Physical Demands	• Existing equipment loads range from ~ 81 to 130 pounds per Marine • MREs and water adequate	• Potential increase in equipment, transported over greater distances • MREs potentially insufficient for greater energy expenditure

The table above contrasts the mental and physical demands on individual Marines engaged in conventional operations with those engaged in DO.

Cognitive requirements for DO are characterized by both decision-making at lower echelons and influencing larger areas of the battle space. The former has already resulted in command training being extended to junior non-commissioned officers (NCOs) and electronic communications being extended below the company level. In the future, the Panel noted, it will also be required to train commanders at the platoon, company, and battalion levels to use DO squads effectively.

The goal of influencing larger areas of the battle space also increases mental demands on Marines as they use ISR systems and products to maintain situational awareness over these larger areas. The larger spatial separations expected in DO may require Marines to sustain operations without relief longer than under conventional doctrine, leading to both physical and mental fatigue and associated conditions (e.g., dehydration and caloric deficit) known to degrade communications and decision-making skills.

With regard to physical demands, individual Marines are already overloaded. In a survey of 10,757 Marines conducting combat and peacekeeping operations in Operation Enduring Freedom (OEF) in Afghanistan and Operation Iraqi Freedom (OIF) during the spring and summer of 2004, it was reported that 86% of the Marines were over the

recommended load limit (Infantry Squad Weight Study, Marine Corps Combat Development Command, February 2, 2005). That limit is set in MIL-STD-1472F, which recommends a maximum load of 30% of an individual's body weight. The larger areas implicit in DO could potentially place increased physical demands on Marines due to the need to transport standard and DO-required equipment over larger distances and due to the real and perceived need to carry extra consumables (rations, water, ammunition, and batteries) to provide unit self-sufficiency.

The Panel as a whole and the human factors/medical subpanel devoted a significant amount of their fact-finding to the enhancement of human performance, in accordance with the request of the Sponsor. Briefings by the U.S. Army Research Institute of Environmental Medicine, in particular, highlighted the relatively bleak prospects for such enhancement despite an aggressive and scientifically excellent program of peer-reviewed research and development.

Physiological performance enhancers have been developed for athletes. However, none of these (e.g., steroids, human growth hormone, amphetamines) is without serious side effects when used over long periods of time. Notwithstanding this fact, other countries, such as Russia and China, are providing these enhancements to their military personnel (Dr. Adam Russell, presentation at the Human Performance Optimization in the Department of Defense: Charting the Course for the Future Meeting, June 7–9, 2006). Further, it was clear from discussions with operational personnel attending this meeting that Marines' use of commercially available nutritional supplements is extremely widespread and without education on variations in quality control and lack of independent evidence of effectiveness. Also widespread was the use of ibuprofen (commonly referred to as Vitamin M from the brand-name Motrin) and other over-the-counter analgesics for the relief of lower back, shoulder, and knee pain.

Given the wide-spread use of nutritional additives, it is critical that the Marine Corps coordinate with the U.S. Army Research Institute of Environmental Medicine (USARIEM) and the Army's Natick Soldier Center (NSC) DoD Combat Feeding Directorate both to provide guidance to Marines and to identify Marine energy expenditure requirements. First Strike Rations (FSRs) have been developed by these institutions specifically to meet the energy expenditures of extended combat operations. They provide 2900 cal in a single package that can be eaten on the move, thus providing higher energy, lower weight, and convenience. Caloric intake is a surprisingly significant factor in human performance. Studies by USARIEM have shown that caloric deficit can lead to cognitive impairment within 48 hours.

With regard to fatigue, the only evidence-based countermeasures are sleep and caffeine. USARIEM and Natick have developed novel delivery means for caffeine (e.g., chewing gum) that are safe and effective. There are no studies suggesting near-term progress on other pharmacological enhancers of cognition.

Thus, the significant potential for DO-induced increased demands on individual Marines occurs in the context of the following findings by the Panel:

1. Currently, squad-level NCOs are not trained to execute missions based on commander's intent.

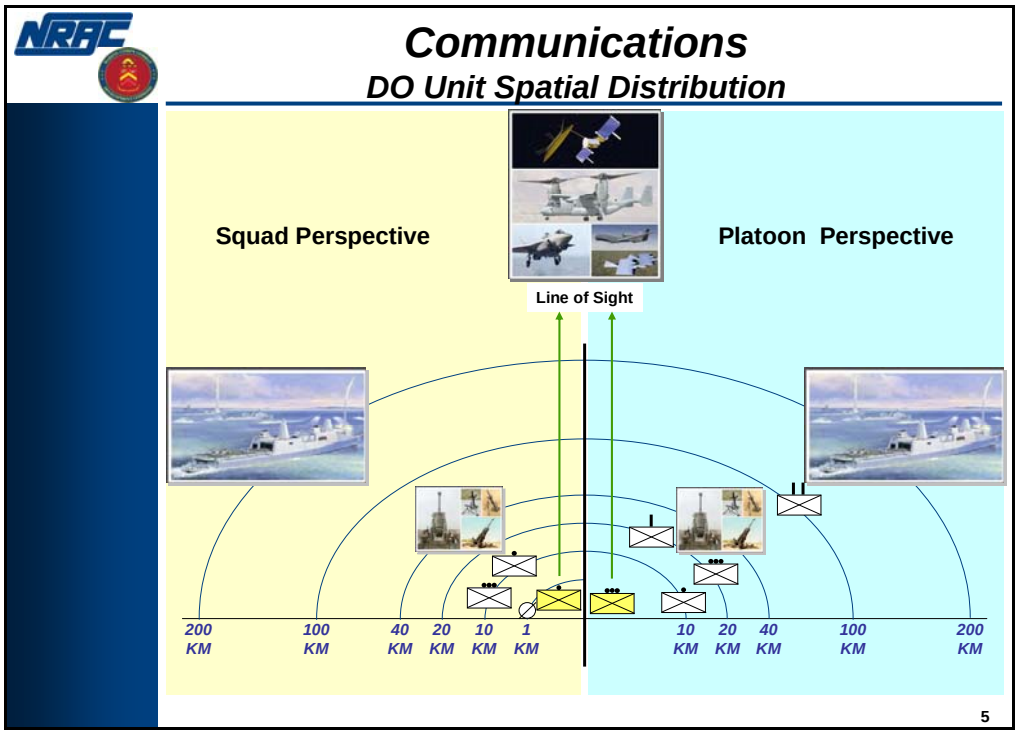
2. The array of communications gear used by Marines is already complex.
3. Cognitive impairment results quickly from fatigue and nutritional deficit.
4. The only safe and evidence-based countermeasures against fatigue are sleep and caffeine.
5. No safe pharmacology-based cognitive enhancements are likely in the foreseeable future.

In short, DO operations are more complex than conventional Marine Corps operations and correspondingly more demanding on the physical and mental stamina of the individual Marine. If not addressed effectively, the increased physical and mental depletion of the individual can have very negative impact. As discussed above, it is essential that the Marine Corps leverage the investment of the Army in nutritional and pharmacological support to infantry. However, given the lack of a nutritional or pharmacological "magic bullet," the greatest leverage available for U.S. Marines comes from education, specifically, enabling the Marine through education and training and education for junior NCOs in the command skills necessary for DO. Another critical point of leverage is communication for control of fires.

Finally, supporting the Marine requires reducing significant individual load carriage through timely and reliable resupply. This provides the greatest leverage since a systems approach to design of the Marine's equipment has been estimated to produce decreases in load weight of about 10 pounds and reductions due to material science enhancements of about the same order. In addition, reliable logistical support is essential to address hydration and nutrition of Marines in combat, particularly in DO scenarios.

The next three sections of this report address these critical points of leverage for enabling DO: communications, education and training, and logistics. The Panel views these as the potential show-stoppers. DO will not be feasible or effective on a large scale without significant advances in all three areas. It is also worth noting that the areas are not completely independent of one another. For example, effective, "autonomic" logistics would require communications infrastructure in addition to that needed directly for support of maneuver and fires.

This page intentionally left blank



Communications

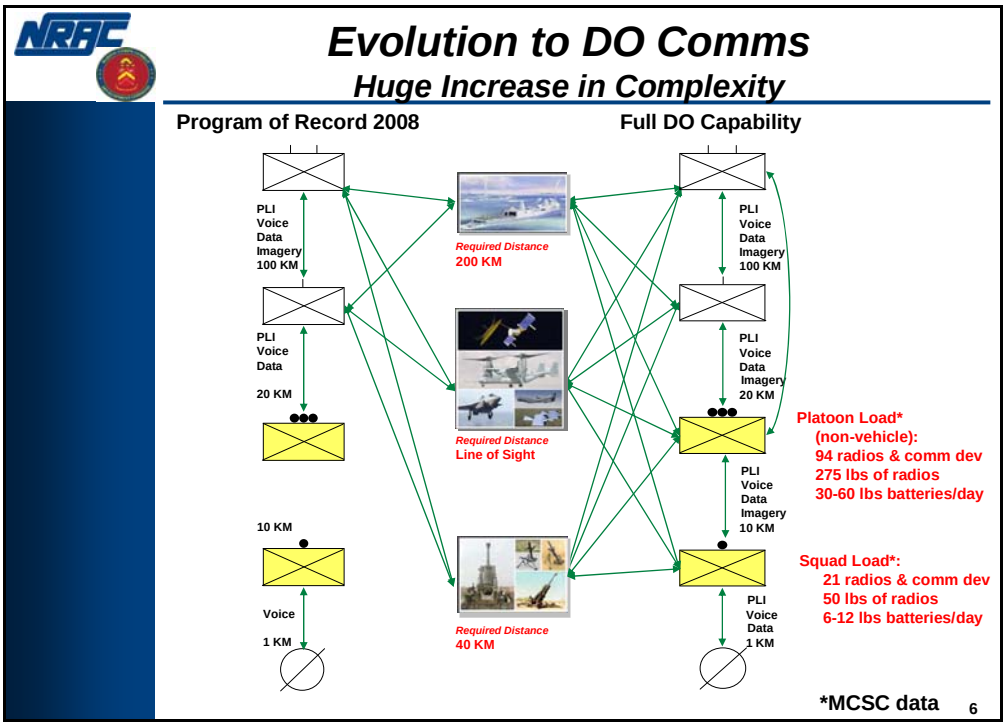
The move to DO at the squad and platoon levels will increase the complexity of the communications architecture and the challenge to connectivity due to increased ranges and functions associated with the empowered unit. This figure depicts the distances between DO units and between DO units and logistics and fires units from the perspectives of the squad (left half) and the platoon, based on specifications by MCWL and the Marine Corps Systems Command (MARCORSYSCOM) shown in the table below.

The figure shows that both the squad and the platoon will have to communicate with entities that previously communicated only with higher echelon units, e.g., forces afloat, artillery units, and aviation units. In addition, the distances between squads and between squad and platoon will be dramatically increased in themselves. This will require new communications equipment, architecture, and doctrine to address basic connectivity as well as the proliferation of nodes on the battlefield. Where before the squad communicated principally within itself, in the future the DO squad will interact with all other friendly fighting units on the battlefield as well as logistics and fires units. Communications must be absolutely reliable to maximize the survivability and lethality of the DO unit.

The criticality of communications to the DO unit can only be appreciated when the substantial difficulty of mutual support at these ranges is considered. The DO unit will be largely alone on the battlefield if, for any reason, its connectivity is compromised. This figure emphasizes the ranges that separate these units. It does not depict distances between the DO unit(s) and other friendly units that might be present on the battlefield, which can complicate the situation significantly.

Inter-unit Separations in Conventional and Distributed Operations			
	Conventional Operations	Distributed Operations Goals[1]	Maximum Communications Range[2]
Rural Area			
Distance between fire teams in a squad	visual	<1 km	1 km
Distance between squads in a platoon	visual	10 km	30 km
Distance between platoons in a company	1 km	20 km	60 km
Distance between companies in a battalion	3 km	100 km	100 km
Urban Area			
Distance between squads in a platoon	Operationally Dependent	1 city block	Obstruction-limited
Distance between platoons in a company	Operationally Dependent	3 city blocks	Obstruction-limited
Distance between companies in a battalion	Operationally Dependent	10 city blocks	Obstruction-limited

[1]As specified by Marine Corps Warfighting Laboratory.
[2]As specified by Marine Corps Systems Command.



The figure above shows, on the left, the links and types of traffic between Marine infantry echelons and remote fires and afloat forces that will be provided by the Program of Record by the end of FY 2008. On the right, the figure shows the additional links and traffic envisioned by MCWL within the DO chain of command, and between infantry and remote fires and afloat forces. Note that the additional links reflect only communications within the squad's chain of command (and to fire support and afloat forces); this diagram does not account for links to other friendly units that may occupy the same or adjoining regions of the battle space. Nevertheless, the significant increase in networking complexity is immediately apparent. In order to provide for communications within the DO construct, initial steps must be taken to augment the capability of the DO units with existing equipment. Using MARCORSYSCOM data, the additional equipment and batteries required to support these requirements for the DO squad and platoon are noted on the right. As discussed in the previous section, it is immediately apparent that this additional burden will exacerbate the physical load carried by individual Marines.

Less apparent, but probably more significant, is the increase in cognitive load on the members of the DO squad. Based on the Panel's observations at 29 Palms, the use of so many discrete systems, each with a somewhat different user interface and undoubtedly with system-specific idiosyncrasies, will almost certainly overwhelm Marines and NCOs at the squad level unless very substantial increase in training is implemented or significant engineering to provide a single user interface is undertaken.

Still less apparent is the impact on overall networking complexity and throughput in the battle space. Although the Panel did not do detailed networking analysis, access to an ASD(NII)-sponsored PDM III study provided additional insight. That study considered a low-density ground warfare scenario that bore operational similarity to DO. In that scenario, packet retransmission between spatially separated units grew to a significant fraction of the overall network load. Further, in the absence of

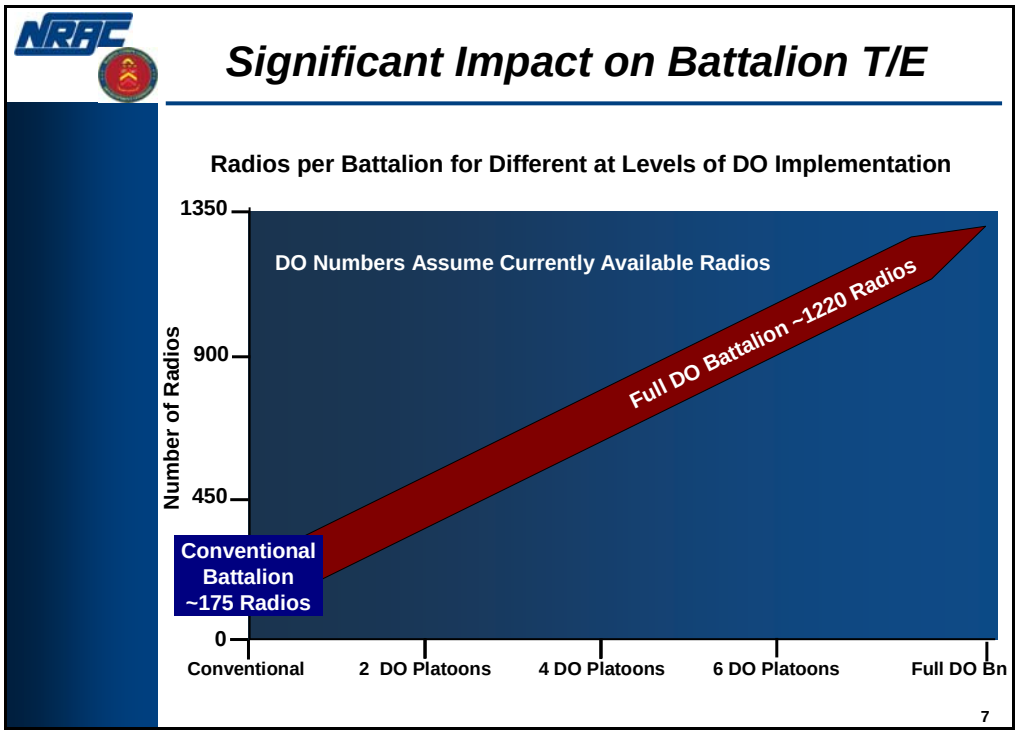
Transformational Communications Satellite (TSAT), spatially diffuse units had the potential to use up a significant fraction of available Mobile User Objective System (MUOS) beams in the battle space. These complications led to a recommendation to develop a frequency-separated, airborne relay layer based on unmanned aerial vehicles (UAVs) so as not to compromise network throughput when many spatially separated units occupy the battle space, *even at low density.*

Note that communications security is yet another complicating factor. Even the use of Type III encryption will have ripples that will significantly affect cost and communications management overhead (such as re-keying). If it is determined that Type I encryption is required, the composite system may well be unworkable with current equipment. This was emphasized by the Panel's observation at DO LOE II that the mix of communications systems required the use of a particular system to keep the clocks of frequency-hopping systems synchronized. This appeared to be an undocumented deficiency in system capability that had been discovered by the Marines in the experimental DO platoon.

Even assuming that secure networking is possible between the DO squad and higher echelons, other friendly units, and remote fires, the extent of squad- and platoon-level RF emission will be significantly higher for DO than for conventional operations. A briefing from the National Security Agency on the effective exploitation of radio emissions (including those not decrypted in any way) by Viet Cong and North Vietnamese Army units during the Vietnam conflict suggests that the Marine Corps should analyze the implications of radio-noisy units against asymmetric opponents.

Finally, the following figure shows that just the linear increase in equipment required to support the previously stated communications connectivity objectives is daunting. When this is done for a full DO battalion, compared to a traditional battalion the radio equipment requirements increase sevenfold. This has obvious implications with respect to cost as well as complexity and accountability on the battlefield. The communications overhead in management and service personnel at the company and battalion levels will have to increase to handle the expanding load.

In the end, the greatest challenge is represented by the change between the traditional communications equipment load of the Marine battalion and that which will be required for DO. With the implementation of DO, the squad alone will need 21 dedicated communications devices as well as the overhead in battery volume and weight to support the communications suite. Other factors, such as the likely need for airborne relays as discussed above, will add complexity to network management as well to the airspace deconfliction problem in the battle space.



The Panel has a number of recommendations for consideration by the Marine Corps with regard to communications in the context of DO. The Marine Corps

1. Should ensure that the requirements for supporting DO are reflected in the ASD(NII)-planned battle space networking architecture, including Joint Tactical Radio System (JTRS). This includes the need to
    a. Determine additional requirements for airborne and SATCOM nodes beyond current plans
    b. Determine the communication requirements for DO logistics and medical support
    c. Focus on DO network experimentation
2. Should engage an honest broker,* independent of the vendors and integrators, for DO network systems engineering and detailed modeling.

* An "honest broker" can be defined as an institution with deep technological understanding in the area of interest (in this case, communications system engineering), without any possibility of profiting during the acquisition or production of the systems about which they are consulted. This may be because the institution has no production capability or because they are prohibited from engaging in production on systems where they provided trusted advice. Federally Funded Research and Development Centers (FFRDCs), University Affiliated Research Centers (UARCs), and other not-for-profit institutions such as Draper Laboratories have all been used by the Department of the Navy as honest brokers.

3. Should explore the acquisition of surrogate radios forward-compatible with JTRS to reduce the radio mass and cognitive load at the small unit level.
4. Should assess small unit vulnerability to exploitation of frequent, highly networked DO tactical communications by asymmetric opponents.
5. Must develop a carefully constructed communications doctrine for DO. The focus of the doctrine, its supporting architecture, and its enabling equipment must be to preserve and enhance the survivability and lethality of the DO units. The clear requirement is for 100% reliability, availability, and security. The price of communications failure is simply too great to ignore.

Logistics

Logistics Element	Conventional Operations	Distributed Operations
Point of Delivery Distribution	Company	Platoon & squad
Logistics Communications Network	GCSS-MC at battalion	Platoon & squad
Equipment/Maintenance Density/Supplies	Marine Logistics Group/ battalion	Order of magnitude change w/increased field units
Logistics Staff	Adequate at battalion Limited at company None at squad	Platoon & squad require logistics-trained NCO

One of the significant challenges for DO will be the ability to provide the squad needed supplies, equipment, and maintenance during extended DO missions at the right time and in the right location and with high reliability. Time and distance are of highest importance when providing logistics support to the disaggregated DO squad; key elements of the logistical system are as follows:

1. Point of Delivery Systems must provide augmented transport for getting supplies to the right place in the shortest amount of time
2. Logistics Communication Network: the Global Combat Support System - Marine Corps (GCSS-MC) must ensure message support from the squad up to the right unit levels in real time
3. Supplies and Maintenance must address the proper equipment and supplies with the lowest possible maintenance issues for the squad
4. Logistics staff must be embedded in the appropriate echelons of the infantry in order to support needs at that echelon and subordinate DO units

The comparison of these elements in the context of conventional and DO is summarized in the table above, and discussed as follows:

Point of Delivery Systems: Today's distribution system is designed to provide support at the company level; for DO, delivery must be provided to the squad at the right time and right place. There are insufficient surface and air assets to achieve logistics support delivery to distributed squads across the battle space. If manned ground transport is used, increased manpower will be required in addition to increased force protection.

Logistics Communication Network: The ability to send alert notices to the logistics support function is critical and constitutes an additional communication function beyond that enabling tactical maneuver and fires. GCSS-MC is the logistics communication program of record, but it currently provides support only to the battalion and not down to the squad, which DO will require. For GCSS-MC to reach down to the squad, the system must address 27 DO squads and the attendant volume of traffic. Currently GCSS-MC has insufficient network capacity and robustness for squad-centric

DO operations. The DO squad will be very limited in its ability to perform "logistical communications" in the midst of doing their mission.

Supplies/Maintenance: Compared to conventional operations, Marines will be on extended missions, and both rapid and timely delivery of supplies will be imperative. If this is not done effectively, the individual Marine's load will grow. It is assumed that the existing Marine Logistics Group (MLG) and infantry battalion is organized, staffed, and equipped to support existing conventional operations. Both the maintenance authority and the quantity of repairable items within the infantry battalion are relatively few as compared to equipment-intensive units (i.e., artillery, tanks, and amphibious vehicles). Infantry battalions fully equipped for DO will see an order-of-magnitude increase in the density of Table of Equipment (T/E) items and in the corresponding maintenance and supply functions to support additional equipment. Currently the reliability, availability, maintainability, and durability (RAM-D) of existing equipment will be challenged to meet the needs of DO.

Logistics Staff: In the context of conventional operations, logistics staff are concentrated at the battalion and higher levels, with a limited capability at the company level; none are present at the squad or platoon levels.

The Panel's findings are as follows:

1. GCSS-MC does not reach down to the squad level and lacks sufficient network capacity to support DO.
2. Sensors and associated algorithms to support predictive, "autonomic" logistics at the company, platoon, and squad levels do not exist.
3. There are insufficient surface and air assets to achieve timely resupply at precision locations over large distances, severely limiting the potential scope of DO in the battle space.
4. Current RAM-D levels are incompatible with DO without very significant increases in maintenance personnel and spares at the battalion and company levels.

The Panel's recommendations with regard to logistics can be highlighted by noting that logistics S&T and modernization must be driven by DO needs if DO is to be successful on a large scale. Recommendations in each of the four logistics elements discussed above follow:

Point of Delivery Systems: As the DO concept matures, augmentation of transport capabilities will be a necessary ingredient to support the disaggregated DO company and platoon. To minimize manpower requirements and reduce the need for the "dull, dangerous and dirty" logistical missions, it is recommended that the Marine Corps acquire (or develop) unmanned systems to provide augmented materiel transport.

1. In an unmanned ground vehicle (UGV) system, or "mule," important features are an autonomous guidance system, cargo carrying, casualty evacuation, troop transport, and battery charging. A hybrid electric vehicle that can provide stealth and mobile electric power should be considered. The Marine Corps should develop the requirements for a UGV capable of supporting DO operations in the mid-term period.

On-going Marine Corps projects such the Joint Light Tactical Vehicle (JLTV) could provide the building blocks for such a UGV. Accordingly, upon the development of operational requirements for such a UGV, the development of the JLTV technologies should be leveraged into an appropriate vehicle for the DO program. In addition, it is recommended that the Marines leverage current SOF acquisition of mule systems.

2. Air delivery systems (both UAVs and low-cost parafoil systems) are potentially important for DO. A vertical take-off and landing (VTOL) unmanned system could provide the ability to deliver supplies with minimal preparation of landing areas. Systems that can handle more than 300 pounds per day will be needed for the squad. The Marine Corps should consider acquiring UAVs such as the A160 Rotorcraft. Built by Frontier Systems (the company is now owned by Boeing), this vehicle is the result of over $100M investment by the Army and DARPA. The A160 can carry about 300 pounds with an endurance in excess of 24 hours. Other UAVs, like Northrop Grumman's Firescout, are also VTOL, carry about 200 pounds of payload, and have an endurance of 6 hours. The Joint Precision Air Delivery System (JPADS) has proven useful for delivering supplies but is considered too costly. Either a lower cost approach must be developed or approaches to recover the JPADS (possibly using unmanned VTOL systems) must be developed.

Logistics Communication Network: GCSS-MC's architecture must be modified to address lower echelons and support the DO squad. Important in this new architecture will be the development of a system integration strategy, the determination of bandwidth needs for the increased nodes represented by DO squads, and the need for a robust peer-to-peer network.

Another important requirement of this communication system is the need to have real-time requests provided by sensors for all of the Marine's equipment or supplies. In the midst of a firefight, the Marine should not be sending his own requests; rather, an "autonomic" system should provide the notices to the GCSS-MC.

Supplies/Maintenance: The DO Marine will be out on missions for longer periods and will have greater independence. Unless the supply system deliveries are on time at the right location, the loads that Marines carry will grow beyond the already too-heavy loads of today. For the DO Marine, it is important that the Marine Corps develops a "Marine as a System" architectural approach. This brings a systems approach to loads that Marines carry, i.e., optimization of the whole system rather than the piece parts. For the first time, load reductions can begin by addressing trade-offs in virtually all that the Marine carries: cross-cutting areas from communication systems, supplies, weapons, food, and water. Future equipment designated for infantry use should reflect not only the performance requirements for their use in DO but also the reliability (RAM-D) challenges associated with it. DO is likely the most stressful operational scenario and therefore should be the benchmark for establishing system reliability key performance parameters.

Logistics Staff: Even if significant "autonomic" logistics is acquired to support DO, it will be necessary for at least one NCO per squad to receive specialized logistics training.

This page intentionally left blank

Education and Training

"Train for certainty ... educate for uncertainty," retired career infantry Master Gunnery Sergeant Dominic Green, USMC (Ret.), advised the Panel. These words succinctly underline the challenge. Traditionally, small unit leaders have been taught the skills necessary for success in combat by employing doctrine and associated tactics, techniques, and procedures whereby decisions are primarily made at company, battalion, and higher command echelons. Thus, there is a large chasm between education and training of a platoon commander and his platoon sergeant and squad leaders. To enable platoon sergeants and squad leaders to perform DO, that gap must be closed substantially. Consequently, one of the principal requirements for DO success is the enhancement of training and professional education for small unit leaders and individual Marines. Their competence needs to include a broad understanding of command and control systems, use of ISR assets, fire support coordination, logistics, and first responder medical care.

Fortunately, the Marine Corps has begun to make the necessary changes, including having completed internal coordination on a comprehensive implementation plan to provide Marines the necessary education and training to execute DO.

The Commanding General, MCCDC, acting in his role as Deputy Commandant for Combat Development and Integration, is coordinating the Implementation Plan to train, man, equip, fund, and support the stand-up of DO capability.

The Infantry Battalion Enhancement Period Program details the model and structure the Marine Corps intends to use to implement DO. The Marine Corps has also instituted key initiatives to better enable Marines to more effectively interact with local inhabitants in irregular warfare, such as the Center for Advanced Operational Culture Learning (COACL) designed to "ensure that Marines are equipped with operationally relevant regional, culture, and language knowledge to allow them to plan and operate successfully in the joint and combined expeditionary environment."

Notwithstanding the planning for education and training supporting DO, the Panel views it as a significant challenge to accommodate the necessary education and training, especially for enlisted small unit leaders, while not seriously decreasing their operational availability. Additional recommendations follow:

- The Panel believes that key enablers will be early identification of candidates that can best take advantage of such training. The Panel encourages the Marine Corps to engage the scientific community to establish evidence-based differentiators allowing such early identification.
- Division-level oversight of individual selection and unit training to ensure DO units are filled with qualified Marines will be necessary. In order to achieve "brilliance in the basics," division-level support will also be required to maintain personnel stability and to accomplish necessary education and field training.
- The Panel believes that ability to assimilate the depth of knowledge required to prepare the new leaders can be enhanced by technology.

Immersive simulation and other new technologies popularly associated with multiplayer interactive games can be used for knowledge transfer and practice of skills that cannot feasibly be supported by live training.

- Finally, mission training plans for DO are under development. The Panel wishes to note that, as part of this process, the Infantry Training and Readiness Manual needs to be updated to include DO training requirements, including the criteria for designating enlisted Marines capable of controlling fires.

Impact of DO on Supporting Establishment

One of the key pieces of amplifying guidance provided by Lieutenant General Mattis to supplement the terms of reference was to consider "higher order" effects on the supporting establishment that enabling DO would require. Such effects have been both implicitly and explicitly noted in the previous sections (for example, the impact of DO's logistics requirements on battalion staffing). However, since the Panel views such higher order effects as very significant challenges to the affordability of DO, the Panel spent substantial time trying to outline them more systematically. This section will discuss the effects noted by the Panel. In general, the Panel has *not* made specific recommendations for addressing these higher order effects in that these effects are frequently beyond the scope of an S&T advisory body. However, in a few instances where the operational experience of our NRAC members and associates or the acquisition experience of NRAC members warranted, the Panel has offered recommendations to accompany its observations.

Infantry Battalion Table of Organization

The contrast between conventional operations and DO, when measured against selected critical support functions of the infantry battalion, is significant. Fundamental differences in supply distribution to field units, volume of collected intelligence, order-of-magnitude increases in the quantity and type of item in the battalion T/E, and the associated maintenance and repair required for these items provide a stark contrast to the present norm. This contrast is all the sharper when multiple infantry battalions simultaneously engage in DO.

The Panel assumed that current infantry battalions have their headquarters and critical internal and external support functions adequately sized for conventional operations. DO and its potentially significant spatial expansion will almost certainly place a strain on existing support manpower and the necessary equipment to perform their functions. With a dramatic increase in "sensors" across the battle space, the volume and real-time nature of that information will tax existing battalion assets available to process, fuse, and disseminate this vital contributor to squad survivability and mission success. Similar stresses will almost certainly impact logistics functions across the board. Ground and air resupply assets, maintenance and repair on a greatly expanded base of equipment, and the associated logistics management tasks (particularly during sustained combat operations) appear to be well beyond the existing infrastructure and associated manpower to accomplish.

During the NRAC DO Summer Study (July 2006), a DO-oriented Limited Objective Experiment (DO LOE-3) was being planned by MCWL that included consideration of logistics. The Panel notes that a robust LOE-3 that evaluates the above issues in depth is clearly a critical opportunity for the Marine Corps to understand the implications of DO on the Infantry Battalion Table of Organization.

Infantry Manpower Management

Contrasting several of the key elements of manpower management as they relate to supporting present and future operational concepts clearly indicates the critical role this function has in enabling DO.

The flow-down of tactical analysis and decision-making responsibilities, coupled with the absolute necessity for advanced regional cultural skills, highlight key differences from present requirements. The demand for more intensive training at the small-unit level and the need to retain such a highly invested force are the key discriminators in contrasting DO units from present conventional infantry formations.

The added operational responsibility, greater technical complexity and numbers of essential warfighting tools, and attendant training and education necessary to enable their effective use are a substantial departure from historic cognitive requirements. Essentially, the DO concept of operations elevates the infantry military operational specialty (MOS) to be comparable to other advanced-skilled, training-intensive MOSs such as aviation or armor. This increased cognitive demand may warrant review of the General Competency Test thresholds currently applicable to infantry at recruitment, as well as additional screening for critical cultural and decision-making skills at accession.

Post-entry and pre-deployment training demands will require new levels of effort for early unit formation and stability. Unit staffing that is extended over time will have a disproportionably negative effect on the ability to achieve DO standards prior to normal lock-on periods.

A much higher level of investment in NCOs and Senior NCOs relative to time and financial resources will be a limiting factor in the gross numbers that can be produced as DO-qualified. As such, these highly invested Marines must be present in operational units longer, or in assignments that have higher correlation to sustaining their MOS proficiency, than other more general assignments. Alternatively, refresher training may be warranted after “B billet” assignments rather than immediate assumption of normal duties within an infantry battalion.

Currently, the incentives for retention, such as time in grade required for promotion, tend to be less for infantry than in the overall force. Retention of NCOs who have received the extensive training needed to support DO will require equalization of such incentives. Even with such equalization of incentives, the relative availability of DO-trained Marines for actual deployment will be significantly lower than current infantry, given the added training required. The Marine Corps should evaluate the need, feasibility, costs, and other ramifications of a longer enlistment period and the concomitant aging of the force.

Medical Support

Implementation of DO necessitates consideration of the following critical medical elements: survivability, combat casualty care, casualty evacuation (CASEVAC), and tracking of casualties.

Survivability in the current asymmetric theater of operations has improved considerably. Less than 10% of casualties are fatalities compared with twice that

percentage in prior conflicts. Highly protective body armor, use of hemostatic bandages, effective tourniquet use, and rapid medical evacuation account for enhanced survival.

In contrast to current operations in which a platoon corpsman is nearly always the first responder to a casualty, in a DO scenario the rifleman at the squad level is likely to fulfill this role. Currently the platoon corpsman trains three Marines per squad in combat lifesaving skills. In the context of DO, it would be highly desirable to have more trained combat lifesavers.

As the operational environment has matured, CASEVAC has become progressively more effective in terms of timeliness and the ability to begin medical stabilization during evacuation to a Forward Resuscitative Surgical Unit (FRSS). This typically is being accomplished in less than 35 minutes from the time of injury. DO will add considerable complexity to CASEVAC because of the inherently greater distance of disaggregated formations from battalion medical support. Wide dispersion of rifle teams will require a higher order of dedicated medical evacuation assets. Likely delays in evacuation associated with the spatial dispersal inherent in DO also argues that combat lifesaver training be deeper than currently, addressing stabilization and support of wounded until evacuation. Tracking of casualties as they move through echelons of medical care will also be inherently more complex.

In summary, DO has significant attendant medical issues with implications for training, communications, and logistics.

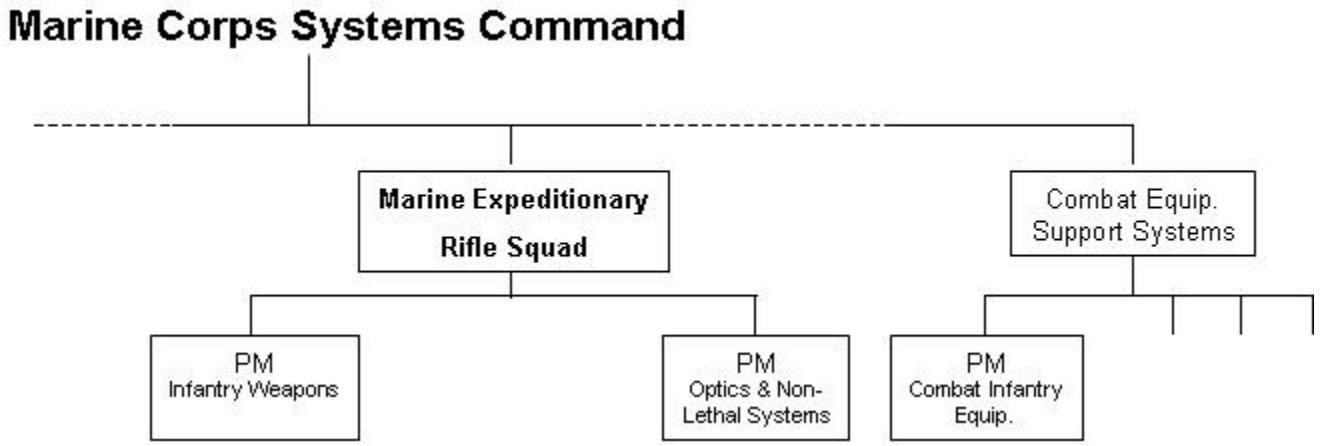
Table of Equipment Acquisition

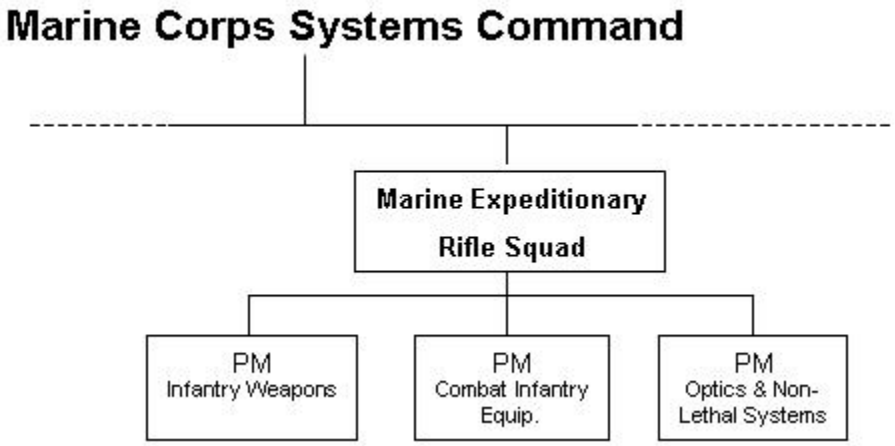
Piecemeal acquisition of the DO-enabled squad's T/E is a virtual recipe for increasing the load that Marines individually, and squads collectively, will carry in the future. Trade-offs among mass, cost, and utility are necessary to optimally equip the Marine rifle squad; just as Lieutenant General Mattis requested that the Panel consider the rifle squad as a system, acquisition for the squad ought to be approached as for any system of systems.

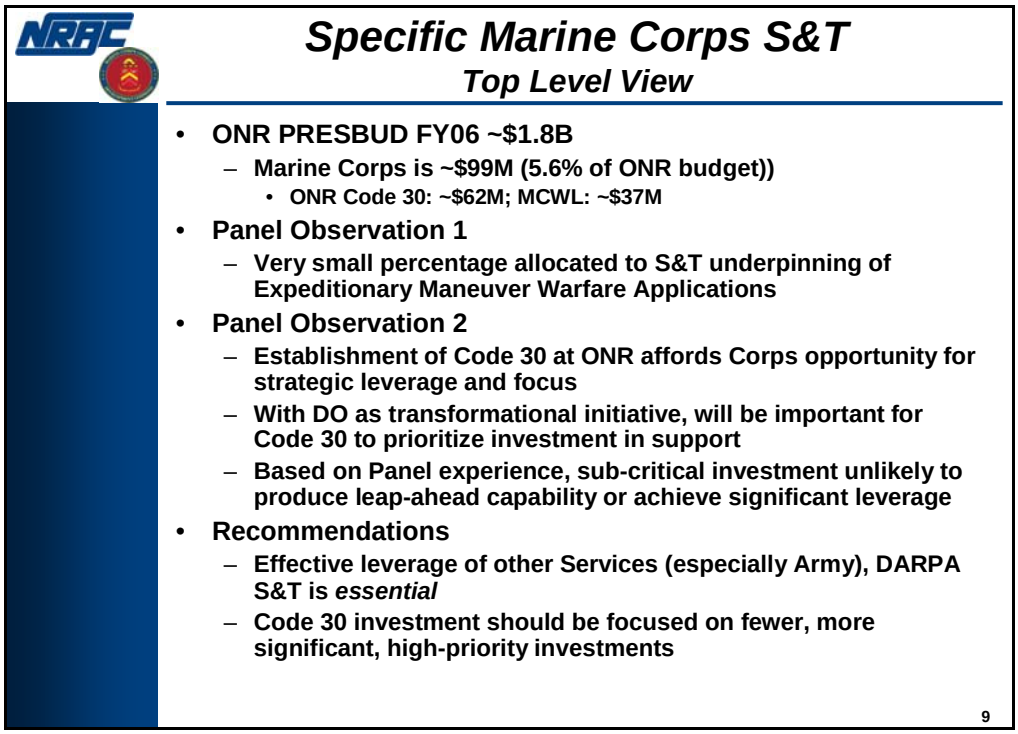
MARCORSYSCOM has established an excellent conceptual basis for such system engineering in the Marine Expeditionary Rifle Squad (MERS) "Program." The last word in the previous sentence is in quotes because MERS is not actually a program of record. Organizationally, it resides at the program level within MARCORSYSCOM, even though its domain of discourse spans multiple Product Groups. Elevating MERS within the Command and consolidating all the programs acquiring elements of the squad T/E would empower MERS to enforce mass constraints and effect mass, utility, and cost trade-offs within the overall T/E. The current and proposed structures within MARCORSYSCOM are shown in the figures provided below.

One possible approach to performing this system engineering trade-off function is known as a "commodity market." It has proven effective in other complex system engineering contexts, such as the development of spacecraft. Previous to this development, it was common for spacecraft to be delivered late, over budget, and substantially below maximum launch mass. This resulted from the spacecraft management team apportioning mass, power, and cost and schedule budgets to the various instruments and subsystems aboard the spacecraft. The subsystem teams

developed their subsystems against these local constraints, typically struggling to meet at least one of the constraints (and violating others); mass, because of fundamental limits of celestial mechanics, was underutilized and schedule was frequently driven by the poorest-performing subsystem team. The introduction of the commodity market approach allowed subsystem teams to trade increments of mass for power, cost for mass, or mass, power, and cost for schedule, etc., and typically yields spacecraft more fully utilizing the available launch mass budget while simultaneously putting less overall pressure on the other constraints at the system level. This approach, well documented in the space industry, may well offer substantial advantages in the engineering and acquisition of a DO-capable squad T/E.







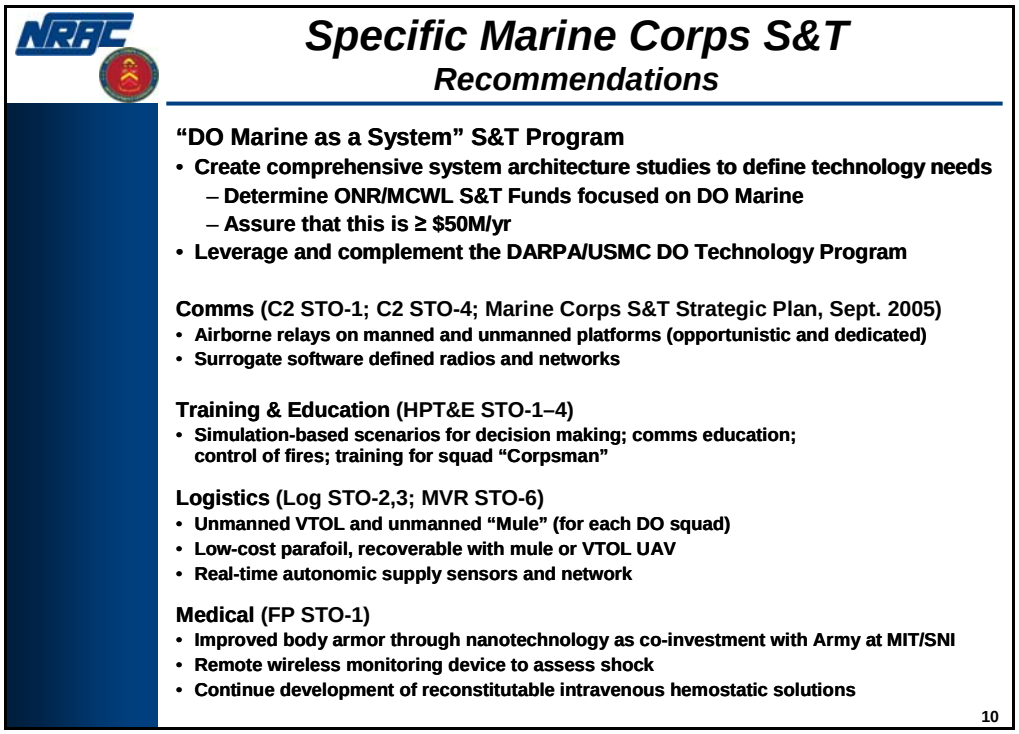
Marine-Specific Naval S&T

Currently ONR provides 5.6% of its ~$1.8B FY 2006 Presidential Budget Request for Marine Corps S&T needs at a total of ~$99M. This amount is divided between the recently created Expeditionary Maneuver Warfare and Combating Terrorism S&T Department, Code 30, and MCWL. The Panel found that such a small level of funding cannot support any reasonable S&T effort for developing Expeditionary Maneuver Warfare capabilities.

In 2005, the decision by ONR and the Marine Corps to establish Code 30 was an opportunity for strategic focus and leverage. With the DO transformational initiative it will be important for Code 30 to begin a prioritization of its programs and to provide focus in support. Based on the Panel's experience, the current array of programs are sub-critical investments and are unlikely to produce leap-ahead capabilities or even enable other efforts in the Services or DARPA to be leveraged effectively.

For Code 30 and the Marine Corps to move out on this DO initiative, it is important that they leverage other people's money and efforts. It is especially important for Code 30 to leverage the Army's significant investments and only fund Marine-unique areas. As DARPA and the Marine Corps begin the DO Technology Program it is important that ONR monitor it closely and find complementary efforts to support this new DARPA-funded program. Finally, Code 30 must take the critical steps to focus on fewer, more significant higher-priority investments.

This page intentionally left blank



S&T Recommendations

The "banner" recommendation from the Panel is for ONR and the Marine Corps to focus and prioritize its efforts on a "DO Marine as a System" S&T Program.

ONR and the Marine Corps should create a comprehensive system architecture study to define technology needs. This should be done in a competitive way with at least three or four contractors working with the Marine Corps and ONR to examine the technology opportunities for the "DO marine as a system." To make this a high priority, Code 30 and MCWL should determine the current S&T funds invested for the DO Marine; these should be focused investments and not just tangentially associated. Importantly, the new program should be >$50M/year; at such a funding level, the Marines can expect leap-ahead capabilities and can expect to better leverage the Army and DARPA efforts. Very importantly, ONR/MCWL should leverage and complement the DARPA-Marine Corps DO Technology Program that is starting in 2007. This would enable DARPA technology success to be more rapidly integrated into the DO Marine Corps program.

The Panel's summary recommendations are in four areas:

1. Communications

- Airborne relays on manned and unmanned platforms (opportunistic and dedicated) are needed to provide the significant connectivity for the DO squad.

- Surrogate Software Defined Radios and Networks are needed since the JTRS program is not delivering the communications in time for DO.

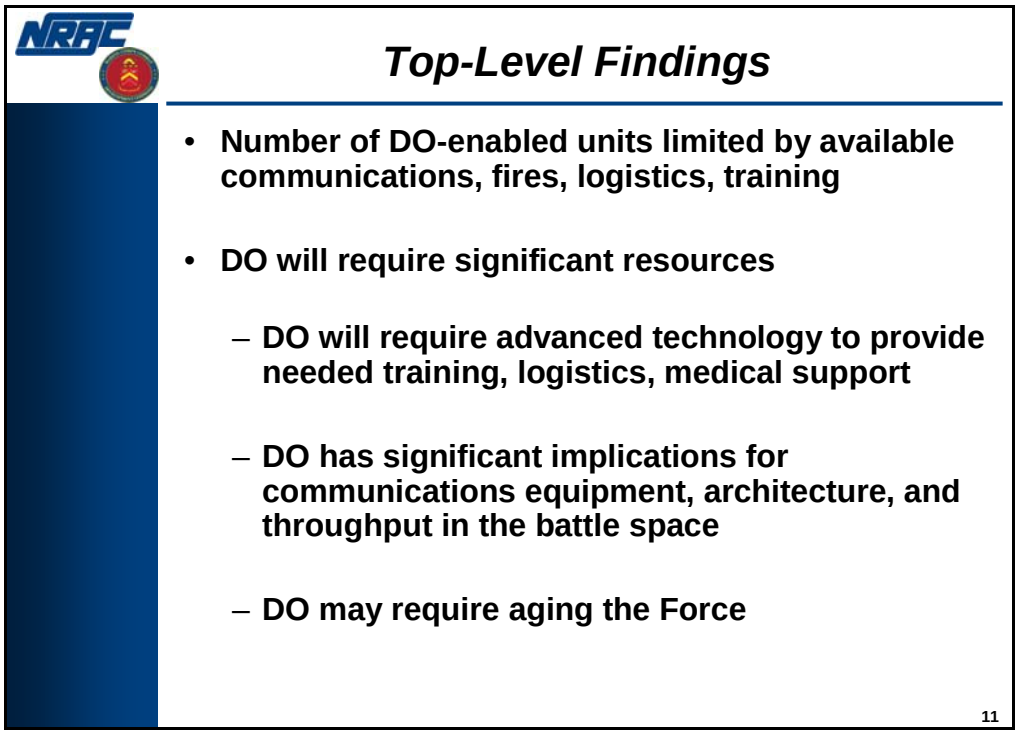
2. Education and Training

- Simulation-based scenarios for decision-making; communications education; direction and control of fires; training for squad-level "corpsman"

3. Logistics

- Unmanned VTOL and unmanned hybrid electric vehicle "mule" (for each DO squad)
- Low-cost parafoil, recoverable with mule or VTOL
- Real-time autonomic supply sensors and network

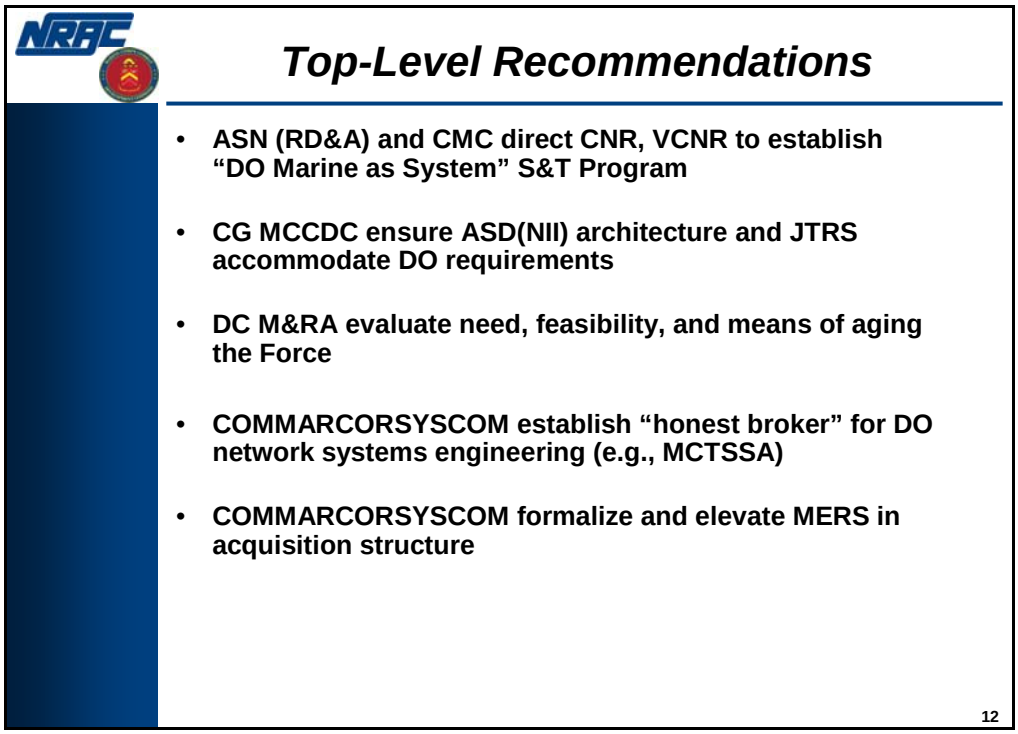
In September 2005 MCCDC published the first Marine Corps Science and Technology Strategic Plan. This plan established the priorities and direction for the S&T investment needed for the future Marine Corps. The plan identified specific S&T Objectives (STOs) that are needed to enable the warfighting capabilities. The S&T investments that the Panel identified above have been correlated to the Plan's STOs as indicated in the figure above.



Top-Level Findings

From a practical standpoint, the number of units that can be supported as DO-enabled is limited by available bandwidth in the battle space, the number and types of supporting fires units, the throughput limitations of the training establishment, and the capacity of the logistics infrastructure. In many of these areas, the availability gap is compounded significantly by the need for live training before a squad can be designated as DO-capable. For instance, a limitation based on the number of artillery units in the Marine Corps is exacerbated when some of these fires units are required by the training establishment. As compared to the current capabilities in each of these areas, significant investment will be required to bring the Corps to some effective level of DO. Advanced technology solutions will most certainly be required to provide training, logistics, and medical support to the levels required by DO. In addition, the development and implementation of DO-compatible communications T/E, architectures, and doctrine will require substantial resources by way of funding, time, personnel, and top-level attention. Finally, the increased cost of training to support DO will have to be traded off against the alternative of improving first-term retention or increasing the initial term of service so that the training load can be contained. Depending on the results of the supporting analyses, this may ultimately require the aging of the Marine Corps workforce to provide personnel with increased maturity and experience to DO-enabled units.

This page intentionally left blank



Top-Level Recommendations

This figure shows the Panel's top-level recommendations, with appropriate assignments for action.

The Panel's principal recommendation is that the Department of the Navy establish a "DO Marine as a System" S&T Program, resourced appropriately for the level of challenge represented by DO as a transformational concept of operations. This will require careful prioritization of Marine S&T investments, significant additional resources from ONR beyond the current program of record within ONR Code 30 and MCWL, as well as effective leverage of investments by DARPA, the Army, and Special Operations Command.

Additional top-level recommendations include the urgent need for MCCDC to ensure that the communications and networking requirements of DO will be supported in planned DoD battle space architecture; the need for the Marines to evaluate the feasibility, desirability, and means of aging the force to maximize return on investment in much more highly trained infantrymen; the need for the Marines to retain or establish an "honest broker" to conduct DO communications system engineering; and the need to elevate the MERS "Program" within the Marine Corps System Command structure to facilitate acquisition of the T/E for DO units with necessary system engineering.

These selected recommendations, called out previously in the report, are the critical actions without which the DO concept will not evolve smoothly. Consequently, the panel strongly urges their adoption and implementation.

This page intentionally left blank

Appendix A

Terms of Reference

Marine Corps Distributed Operations
NRAC Summer Study 2006

Objective

Study the emergent concept of Marine Corps Distributed Operations in order to develop a set of technology insertions and training opportunities over the coming decades. This study will identify time-phased insertions based on capability requirements and shortfalls and address the risk associated with various courses of action. The study should expand on current concepts and models regarding power, protection, logistics, performance and training.

Background

The most critical component of Distributed Operations is the secure, mobile, flexible, and lethal Marine rifle squad. The capability challenges to this component are primarily in the areas of either equipment or training. Specific challenges to today's distributed operations include:

1. An excessively heavy combat load carried by the individual Marine threatens the squad's mobility and persistence;
2. Marines are vulnerable to enemy small arms;
3. squad communications equipment emits strong and persistent radio signals, while being limited to line-of-sight;
4. the squad's non-integrated situation awareness and data collection systems place unrealistic training burdens on the Marines, and can divert the Marine's attention from the task at hand;
5. the squad's equipment consumes large amounts of electrical power, supplied by a variety of batteries, increasing weight and re-supply challenges;
6. and finally, the squad must be resupplied, often in environments where anti-air threats make conventional helicopter operations difficult.

Possible mitigation of these challenges may involve a system of systems approach enabled by emerging technologies in materials, communications and information, nanotechnology, etc.

Specific Taskings

This study will specifically:

1. Compare and contrast the required capabilities of Marines conducting Distributed Operations and with those required by current operations.
2. Determine appropriate options for insertion of technology to support Distributed Operations and associated training; key upstream investments, technology monitoring, and go/no-go assessment points; and probable time frames for exploration and implementation

3. Estimate the risk associated with particular options, and identify potential show-stoppers

Appendix B

Briefings

LtGen James N. Mattis, USMC	Commanding General, MCCDC
RADM William Landay, III, USN	Chief of Naval Research
BGen Douglas M. Stone, USMC	CG, MCAGCC
Dr. Robert Douglas	Army Science Board
Col Meyers, USMC & Panel	I MEF
LtCol Kennedy, USMC & Panel	I MEF
LtCol Timothy Mundy, USMC & Panel	II MEF
LtCol James P. West, USMC	Intelligence Dept, HQMC
Mr. Rich Stauffer	Installations & Logistics, HQMC
Col John Hull, USMC	MCCDC
Maj Pat Cashman, USMC	MCCDC
Mr. Erik N. Doyle	MCCDC
Mr. Chris Zaffram	MCCDC
Dr. George W. Solhan	ONR
Mr. Vince J. Goulding	MCWL
LtCol Chris Carolan, USMC	MCWL
LtCol Jon Jacobs, USMC	MCWL
Maj John Giscard, USMC	MCWL
Col M. Mulligan, USMC	MCSC
Mr. David Hansen	MCSC
Mr. J.D. Wilson	MCSC
Mr. Robert Hobart	MCSC
Mr. Mike Davis	MCSC
LtCol Ed Tovar, USMC	DOAS, DARPA
MAJ Marco J. Barrera, USA	Future Force Warrior, PEO Soldier
Mr. James L. Hillman	JHU/APL
Dr. Robert Hanyok	NSA
Mr. Bill Harris	Future Force Warrior, PEO Soldier
Dr. Jim Korris	Institute for Creative Technology, USC

Dr. Robert Playter	Boston Dynamics, Inc.
Dr. Edwin L. Thomas	Institute for Soldier Nanotechnology, MIT
Dr. Michael Zyda	Gamepipe Laboratory, USC
MGySgt Dominic Green, USMC (Ret.)	
LTC William Utroska, USA	CERDEC
Mr. Scott Meyers	General Dynamics
LTC Carl Hover, USA	US Army Medical Research & Materiel Command
Dr. Andrew J. Young	USARIEM & Natick Soldier Center
Dr. Gary H. Kamimori	Walter Reed Army Institute of Research
Mr. Jason L. Rottenberg	OnPoint Technologies
Dr. Edward Hirsch	Natick Soldier Center
CDR Ginny Raderstorf, USN	National Naval Medical Center
Dr. Karl Van Orden	Naval Health Research Center, San Diego

Appendix C

Panel Membership

Dr. John C. Sommerer, Chair
Johns Hopkins University
Applied Physics Laboratory

BGen James M. Feigley, USMC (Ret**.), Vice Chair**
NRAC Associate

Dr. A. Michael Andrews II
L-3 Communications

Dr. Fernando "Frank" L. Fernandez
Consultant

MajGen Paul Fratarangelo, USMC (Ret.)
NRAC Associate

Dr. Valerie J. Gawron
Army Science Board
General Dynamics

VADM E. R. Kohn, USN (Ret.)
NRAC Associate

Dr. William A. Neal, MD
West Virginia University

Mr. Norman Polmar
U.S. Naval Institute

RADM John T. Tozzi, USCG (Ret**.)**
L-3 Communications

Dr. Christopher B. Wallace
Army Science Board
Northrop Grumman

Sponsor Representatives
Dr. George Akst
Senior Analyst, MCCDC

Mr. Stephen L. Cabrian, Executive **Secretary**
MCCDC

Mr. Roy V. Toliver, Executive Secretary
MCCDC

This page intentionally left blank

Appendix D

Acronyms and Abbreviations

CASEVAC	casualty evacuation
COACL	Center for Advanced Operational Culture Learning
DARPA	Defense Advanced Research Projects Agency
DO	distributed operations
FFRDC	Federally Funded Research and Development Center
FRSS	Forward Resuscitative Surgical Unit
FSR	First Strike Rations
GCSS-MC	Global Combat Support System - Marine Corps
GIG	Global Information Grid
ISR	intelligence, surveillance, and reconnaissance
JLTV	Joint Light Tactical Vehicle
JPADS	Joint Precision Air Delivery System
JTRS	Joint Tactical Radio System
LOE	Limited Objective Experiment
MARCORSYSCOM	Marine Corps Systems Command
MCCDC	Marine Corps Combat Development Command
MCWL	Marine Corps Warfighting Laboratory
MERS	Marine Expeditionary Rifle Squad
MLG	Marine Logistics Group
MOS	Military Occupational Specialty
MUOS	Mobile User Objective System
NCO	non-commissioned officer
NRAC	U.S. Naval Research Advisory Committee
NSC	Natick Soldier Center
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
ONR	Office of Naval Research
OODA	observe, orient, decide, act

RAM-D	reliability, availability, maintainability, and durability
SOF	Special Operations Forces
S&T	Science & Technology
STO	S&T Objective
T/E	Table of Equipment
TSAT	Transformational Communications Satellite
UARC	University Affiliated Research Center
UAV	unmanned aerial vehicle
UGV	unmanned ground vehicle
USARIEM	U.S. Army Research Institute of Environmental Medicine
VTOL	vertical take-off and landing